Raising giant tortoises

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Abstract

Captive breeding and rearing giant tortoises still represents a challenge and little scientific evidence is available on the requirements of juvenile and adult giant tortoises. Zoo veterinarians must know that developmental diseases are the main risk in the raising process. Respiratory tract disease, endoparasites and biting are other pathologic conditions that have been observed in juvenile giant tortoises. The fast growth observed in giant tortoises must controlled by limiting the amount of food and reducing digestibility. Giant tortoises are well adapted to a high fiber, herbivore diet. Special attention must be given to the mineral supplementation and photoenvironment.
Raising giant tortoises

Jean-Michel Hatt

Introduction

Only few institutions have been successful in regularly breeding and raising giant tortoises. The knowledge is still small and only little scientific data exists. Much of the published peer-reviewed data on the topic has been generated from Galapagos tortoises at one facility (Zurich Zoo, Switzerland). Although the author has taken great care to collect scientific data from as many sources as possible, large parts of this chapter still reflect personal observations. It is to be hoped that in the future the information given here, will be subjected to scientific analyses, to allow a transition from experience-based to evidence-based raising of giant tortoises.

The order tortoises Testudines include the families Testudinae and Emydidae. The Testudinae comprise 14 genera. From fossils it is known that several Testudinae existed as giant forms on all continents except Australia and the Antarctica. Today giant tortoises have survived on Aldabra, the Seychelles and the Galapagos islands. The taxonomy of the surviving genera is still under debate and the different nomenclature is summarized in table 1. In the present text the terms Geochelone nigra and Geochelone gigantea will be used for Galapagos tortoises and Seychelles tortoises, respectively.

Insert Table 1 here.................................................................
The current number of Galapagos tortoises is estimated at 12 – 15’000 (Schramm 1998) and the Seychelles tortoises at 100’000 (Bourn et al. 1999). All giant tortoises are listed by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES): Seychelles tortoises are classified under Appendix II and Galapagos tortoises under Appendix I. The major threat to giant tortoises is feeding concurrence by introduced domestic animals, especially goats, dogs and pigs as well as predation by rats. In addition, illegal trade sill has a significant negative impact on population densities especially in the Seychelles tortoises. In 2002 fewer populations of Galapagos tortoises were affected by food concurrence. Wild pigs and dogs on Santiago and Isabella Islands have been eradicated. The islands of Pinta Espanola and Santa Fe no longer have goats. Goats are still present in Isabela, Santiago and San Cristobal (Marquez et al. 2004).

Unfortunately, Galapagos tortoises face a new threat, which is habitat reduction. The Archipelago prosper and has the highest overall standards of living of any province in Ecuador. This has caused massive increases of the human population of the islands. In an area where 95% of the land is a national park, this leads to conflicts.

Considering that the survival of giant tortoises is far from secure, captive breeding is critical. Breeding programs exist both on the Galapagos islands (Charles Darwin Research Station) and on the Seychelles islands (Seychelles Giant Tortoise Conservation Project). Breeding outside these islands is of importance to eliminate exportation of wild animals but also for educational and scientific purposes.
Unique Anatomy

The two species of giant tortoises can readily be differentiated by the form of their head and the carapax (Table 2). Adult giant tortoises can grow to a straight carapax length (sCPL) of over 130 cm and a bodyweight of 300 kg. Seychelles tortoises are approximately 20% smaller and less heavy than Galapagos tortoises.

The general anatomy of giant tortoises is comparable to that of Testudines in general. Of special interest for breeding is sex differentiation. Adult animals can readily be differentiated externally based on plastron and tail. As in many other tortoises adult males have distinctly longer tails than females and the plastron is concave. Sexing hatchlings and juvenile giant tortoises however, is not readily possible. A possible way to differentiate sex in Seychelles tortoises is the number of tail scales. As the tail grows the scales elongates, but new tail scales are not formed. Female Seychelles tortoises were found to have 8 – 11 scales while males have 12 – 14 scales (Gerlach 2003). This method has not been investigated in Galapagos tortoises.

Endoscopic sexing has successfully been performed in Galapagos tortoises from 12 months of age onward. The ovary with primary follicles or the inactive testicle can readily be visualized (Figure 1 and 2). Access with a 2.7 mm rigid endoscope with a 30 degree distal lens offset is from the left prefemoral region as in other chelonians. Carbon-dioxide is used for insufflation.
Captive management of giant tortoises

Due to their large body size, captive management of giant tortoises can be a challenge outside their natural climatic condition. The following describes the enclosure of Galapagos tortoises at Zurich Zoo, were successful breeding has occurred (Honegger in press). Three adult and four juvenile animals are kept in a combined indoor (65 m²) outdoor (400 m²) enclosure. The outdoor enclosure has a 12 m² shelter that offers constant temperatures of 27°C. The animals remain on the outside enclosure as long as night temperatures do not fall below 15°C.

The indoor enclosure has a 30m² heated surface (24°C). For oviposition a special nesting area has been prepared which measures 2 x 3 m. The depth is 50 cm and it is filled with sand. This area is under 24 hour lapse-time video supervision during months when oviposition is expected. This allows safe removal of the clutch for artificial incubation. Special attention is given to the photoenvironment of the indoor environment. A solarium with infrared and ultraviolet light offers twice a day a local hotspot of 38°C for 30 min, usually after feeding. Special high intensity mercury light sources are used, with the aim to expose the animals to a full-spectrum light. By definition full-spectrum has a color temperature of 5500°K, a color-rendering index of 90 and above, and a spectral power distribution for UV as well as visible light similar to that of open-sky natural light at noon. Relative humidity in the inside enclosure is 60 – 70%. Both inside and outdoor enclosures have a shallow pool which giant tortoises like to use. A mud wallow is not available but would be an important addition, since giant tortoises are known to readily use them. In our experience a mud wallow in the outside enclosure has the disadvantage that animals remain in the mud when temperatures drop and it is
difficult to remove an adult giant tortoise from there without the risk of causing damage to the carapax.

**Nutrition**

Numerous Seychelles and Galapagos tortoises are kept in many zoos and institutions around the world. Despite this surprisingly little is known about the exact nutritional needs of these animals. Even less is known of the requirements of juvenile giant tortoises. Possible nutrition related disorders are (excessive) geophagy with subsequent constipation, loose stools, bloat and metabolic bone disease. A questionnaire evaluation showed that zoos keep Seychelles tortoises mainly on domesticated fruit and vegetable or grass, hay and other roughages. Such a diet is not adequate. Giant tortoises are herbivorous and their natural diet consists of grass, leaves, flowers, and fruits. In the wild giant tortoises consume what is described as tortoise turf, a complex of grasses, sedges, and herbs (Edwards 1991). In Seychelles tortoises an apparent dry matter digestibility of 30% was measured for the turf. Carnivory and coprophagia has been observed, but does not make more than 0.5% of the total ingested diet. Seychelles tortoises appear to be more of a graser, in contrast to Galapagos tortoises which are more of a browser. To reach higher leaves and flowers it has been observed that animals climb on top of each other. Additionally, browsing species develop a saddle-shaped carapax, that allows better vertical extention of the head, compared to the dome-shaped carapax. Giant tortoises are well adapted to increase their growth rate during vegetation periods. In their natural habitat giant tortoises loose significant amounts of weight during dry season.
In contrast to vegetation period when body fat depots are produced. During dry periods giant tortoises increase digestibility of the diet by increasing intestinal transit time by a factor five. A longer transit time allows the gut flora more time for fermentation which increases digestibility.

The diet of juvenile giant tortoises at Zurich Zoo consists to 90% of a chopped high quality grass hay. To this a variety of herbs, dried leaves and occasionally produce are added. The amount of fresh food offered to hatchlings and juvenile up to four years varies between 3-5% of their body weight per day.

Giant tortoises are well adapted to a diet rich in fiber. Four captive bred juvenile Galapagos tortoises aged four and five years were fed a controlled diet for 32 days. The diet consisted of 77% hay, 15% tortoise pellets, and 8% apples on a dry matter basis. Diet analysis revealed on dry matter basis: 95.7% organic matter, 11.3% crude protein, 20.5% crude fiber, 22.6% acid detergent fiber, 5.0% acid detergent lignin, and 17.6% cellulose. Based on total fecal collection during seven days the following average dry matter digestibilities were calculated: 65% for dry matter, 67% for organic matter, 63% for crude protein, 55% for crude fiber, 49% for acid detergent fiber, 41% for acid detergent lignin, 54% for cellulose. Compared to mammalian hindgut-fermenting herbivore species (domestic horses, Asian elephants, Indian rhinoceroses) on a diet of hay and concentrates, the juvenile Galapagos tortoises showed a digestion of similar efficiency. An increase in crude fiber content resulted in a reduced digestibility. If a reduction in dietary digestibility is to be achieved in juvenile Galapagos tortoises, crude fiber levels of 30 – 40% on a dry matter basis should be aimed for (Hatt et al. 2005).
Adequate calcium (Ca) supplementation is critical for the healthy development of giant tortoises. Oystershell powder and calcium carbonate has successfully been added to the diet. In juvenile Galapagos tortoises we found that an increased Ca to phosphorus (P) ratio did not result in a reduced Ca uptake (Liesegang et al. 2001). Apparent Ca digestibility at a Ca:P level of 4:1, 5:1 and 7:1 was 42%, 63% and 82%. P digestibility increased too. Therefore similar to mammalian hindgut fermenter such as rabbits and horses increased dietary calcium concentrations result in increased digestibility. Excessive calcium is excreted mainly via the urine. An optimal Ca:P ratio of 4 – 6:1 is recommended. Oversupplementation may result in Ca concretions in the bladder and could result on urolithiasis.

Frequent drinking of water was observed in Aldabran tortoises and it is recommended that juvenile giant tortoises in general should always have access to water (Chida 1998).

**Breeding giant tortoises**

Captive management of giant tortoises has a relatively long tradition in European zoos. In 1960 a census showed thirty Galapagos tortoises in thirteen European collections with the majority being males (Honegger pers. comm.). The reason for this male dominance was that zoos were mostly interested in exceptionally large specimens. Due to longevity of giant tortoises this bias towards males still today has an influence on the sex ratio of captive the giant tortoise population. Management of these male dominated groups was often unsatisfactory. In the summer the animals were kept outside and had
barely heated shelters for colder days, in winter they were confined in small overheated, humid shelters. Under these circumstance it is surprising that the first successful breeding of Galapagos tortoises occurred already in 1939 at North Miami Zoo and the Bermuda Aquarium. Since then, breeding of Galapagos tortoises has been successful at the San Diego Zoo (1958), Honolulu Zoo (1967), Philadelphia Zoo (1975), Gladys Porter Zoo (1986), Life Fellowship Bird Sanctuary Florida (1987) and Zurich Zoo (1989). It is only since the 80s that some institutions have had regular breeding success. Between 1990 and 2003 Zurich Zoo has raised 50 Galapagos tortoises.

First breeding of Seychelles tortoises outside its natural habitat was in 1976 in Sidney. Currently, regular breeding occurs only in Mauritius and Seychelles, with occasional reproduction in Britain, the USA, Australia and Japan. Despite these highlights reproductive success under captive conditions is still low compared to the number of giant tortoises kept.

Reports from the Seychelles Tortoise Conservation Project suggest that spatial and social variability play an important role for successful reproduction. It is recommended that social groups should not be heavily male based. One male should be significantly larger than the others to reduce aggressive encounters within the herd (Gerlach 2003). There seems to be a hierarchy with the largest male mating the most. Chida (1998) hypothesized that females above 70 – 80 cm carapax length loose the breeding capability since they chose larger males, which at a certain carapax length would not be possible. Females must be able to avoid males, and male-male competition has been shown to stimulate breeding. Keeping large groups of at least 12 animals
together appears to increase breeding activity. Best breeding was found were animals had much space (30m² per animal).

Mating can be observed during the whole year. But copulation does not always take place. Most mating is observed in the summer months when temperatures are above 23°C in the morning and the late afternoon. In the Northern hemisphere mating season is from June to October. Oviposition takes place between November and March, usually during the night. In the Southern hemisphere copulation takes place from February to May and oviposition is from June to September. Several days before egg laying, the female shows a more active behavior, wandering around, sniffing and testing the nesting area. In the absence of such an area it has been observed that eggs are laid anywhere.

Ultrasound examination in Galapagos tortoises has shown that follicles became preovulatory at a diameter of 40 – 42 mm and eggs were laid 34 – 84 days after thinshelled eggs were detected in the oviduct (Casares et al. 1997). Eggs with shells may also be retained until the next breeding season, without ill effect. Dystocia has not been reported but the risk is certainly increase if no adequate area for oviposition is offered.

For successful artificial incubation of eggs of Seychelles tortoises need at least 80% humidity and temperatures between 28 – 31°C. Temperatures above 29°C appear to result in females (Gerlach 2003). At temperatures between 28 – 30°C incubation lasts 125 – 136 days whereas at temperatures between 30 – 32°C hatching takes place after 90 – 94 days. At hatching Aldabran tortoises weigh 40 – 70 g and have a carapax length of 50 – 80 mm.
At Zurich Zoo Galapagos tortoise egg incubation is at 29 – 32°C with 65% humidity. Once daily the incubator is ventilated. Incubation lasts 105 – 164 days and has lead to a majority of female offspring. Incubation and hatching takes place in a dark environment. At hatching Galapagos tortoises weigh 50 – 80 g and have a carapax length of 60 – 80 mm.

Candling of eggs has been described and it appears that with 3 – 4 weeks fertile eggs can be recognized by the opacity of eggs in comparison with unfertilized eggs. From piping to hatching it takes approximately two days. In our experience it is neither necessary nor advisable to help hatching animals. After hatching the tortoises are left in the incubator for up to five days, when the yolk sac has been completely absorbed. After five days the animals are offered food for the first time.

The young tortoises are kept in groups in boxes with a floor heating at 26°C. An infrared and a full-spectrum lamp illuminate the enclosure. A 12 h day 12 night photoperiod is chosen. The substrate is coarse gravel with a diameter of 5 mm which is considered to reduce the risk of constipation and erosion by quartzsand as seen in other land tortoise hatchlings. Other institutions have used other flooring material such as grass hay, carpet and rabbit pellets. Alfalfa pellets do not appear to be suitable as litter due to their high protein level, which may lead to developmental disorders due to fast growth. Young Galapagos tortoises are shy compared to Mediterranean tortoises (*Testudo* spp.) and often retreat under the vegetation or within holes. It is recommended to at least twice weekly soak juvenile giant tortoises in lukewarm water for an hour, it improves hydration.
and stimulates defecation. When the tortoises reach a straight carapax length of 35 cm, they have successfully been kept together with adult animals.

**Growth of giant tortoises**

The major challenge in raising giant tortoises is their tendency of fast growth. At the age of 15 – 20 years fast growth is slowed, which coincides with reaching sexual maturity. Giant tortoises on Aldabra on a poor diet and little water grew to 20 – 23 cm straight carapax length (sCPL) at the age of 4 years.

Under captive conditions we could show that juvenile Galapagos tortoises at an age of 4 years were twice as long and weighed 10 times more compared to animals under natural conditions at the Charles Darwin Research Station on the Galapagos Islands (Furrer et al. 2004). This phenotypic plasticity enables the tortoises to adapt their growth to their feeding conditions. A faster growth may lead to sexual maturity at younger age and shorter life expectancy, based on findings in gopher tortoises (*Gopherus polyphemus*) and crocodiles (Furrer et al. 2004).

Since fast growth may also result in developmental disease such as pyramiding which cannot be reversed, it is advisable to carefully monitor the growth of juvenile giant tortoises. Up to an age of 4 years the tortoises are measured (Figure 3) and weighed at least twice a year at Zurich Zoo. The following formulas exist to assess the relation between bodyweight and carapax length:

Jackson’s ratio for Seychelles tortoises

\[ sCPL = 17.5 \times W^{0.345} \]
(sCPL = straight carapax length in cm; W = weight in kg) (Spratt 1990)

and

\[ W = cCPL^3 \times 0.075 \]

(cCPL = curved carapax length in cm; W = weight in grams)

**Restraint and handling**

**Mechanical immobilization**

Small giant tortoises can easily be immobilized as it would be done with the more common tortoise species. The animals are very docile and the risk as far as biting is concerned is minimal. Careful handling is important with tortoises up to two years since the plastron are still soft and compression of inner organs may be a risk. Mechanical immobilization, e.g. for weighing or radiographs, of any size of tortoise can be achieved by positioning the animal on a flower pot (Figure 4). For dorsal positioning of larger animals a car tire is very practical. In addition the juvenile animals should be trained to elevate the carapax from the ground when being scratched on the neck or when food is offered. This training is helpful when they become adults, where it allows certain medical procedures such as ultrasound examination of the coelomic cavity without stress.

**Anesthesia**

General anesthesia has been carried out in giant tortoises from one year of age onwards, with a body weight of 300 g and larger. For endoscopic examination the author
repeatedly successfully used a combination of medetomidine (0.1 mg/kg intramuscular) and ketamine (10 mg/kg intramuscular), which led to deep sedation followed by intubation and isoflurane anaesthesia. Antagonization was performed with atipamezole (0.5 mg/kg subcutaneous). In larger animals propofol 5 mg/kg intravenous has been used.

Noninfectious diseases in juvenile giant tortoises

Developmental metabolic disease

Giant tortoises are arguably the land living vertebrate which shows the highest increase of bodyweight from birth to adult. With a weight at hatching of 80 g and an adult weight of 250 kg this represents an increase of more than 3000 times! In comparison, an elephant which is born with approximately 100 kg increases its weight by only 40 times until adulthood. From reports in rearing of captive giant tortoises it appears that developmental disease, especially metabolic bone disease (MBD) represent a major problem. Metabolic developmental disease has not been observed in the wild. MBD is not actually a single disease but a collection of medical disorders that affect the integrity of the skeleton and in tortoises includes also the development of the carapax and plastron. According to Mader (2006) it is important to differentiate between MBD of nutritional (NMBD) and renal (RMBD) origin. In growing giant tortoises NMBD is predominant and presents as different stages from hypomineralization to fibrous osteodystrophy of bones and pyramiding of the carapax. Pyramiding is characterized by excess growth of scutes on the carapax, with resultant pyramid shape of each scute.
No single etiological factor was identified that causes developmental disease in giant tortoises. It should also be noted that no scientific experimental data is available regarding the prevention or treatment of developmental disease in giant tortoises. A major predisposing factor is most probably the phenotypic plasticity that enables giant tortoises to grow at an increased rate when food is available in large amounts. Under captive conditions this is usually the case, furthermore hatchlings do not need to be very active for feeding. It appears reasonable to reduce food intake to a minimum, which is achieved by the amount and the digestibility.

High dietary protein levels should be avoided in the diet since they have been repeatedly linked to pyramiding and developmental disease. Hauser et al. (1977) describe four Aldabra tortoises which were imported at the age of six months and which developed fatal MBD within 10 to 12 years. All animals showed softening of the carapax, pyramiding and histologically osteodystrophia fibrosa was diagnosed. The diet consisted of roughage, produce, a mineral and vitamin mix. Three times a week 1 kg of minced meat and 1 – 3 eggs were offered to 15 animals. It appears reasonable to assume that these animals had excess protein in their diet. The role of protein level in the diet is controversial. Galapagos tortoises of the same age did not develop any disease, although they were kept under identical conditions. In African spurred tortoises (Geochelone sulcata) no effect of varying protein levels between 14 and 30% on a dry matter basis were found over a period of five months (Wiesner and Iben 2003). In the same study lower levels of humidity resulted in significantly increased pyramidal growth of the carapax. Further studies a warranted to corroborate thses findings in relation to giant
tortoises. In the meantime it is advisable to offer juvenile giant tortoise areas with at least 50% relative humidity.

Other factors have also been suspected to lead to developmental disease. Häfeli and Zwart (2000) described in juvenile Testudo spp. that endoparasites, nephropathy and typhlohepatitis are possible causes for pyramidal shell development. In addition, young Giant tortoises should receive adequate UV illumination. Since no experimental data is available on what adequate is, direct sunlight exposition should be made available whenever possible. At times this may be difficult, when animals are kept under temperate conditions. The use of UV-permeable roof systems may not result in an adequate photoenvironment. Analyses by Ebersbach (2001) at Hannover Zoo showed that approximately 30% of UV A and UV B passed through such a roof. In the absence of experimental data, special UV light systems for reptiles have to be installed at suitable distance from the animals to offer adequate UV A and UV B. At Zurich Zoo high intensity discharge mercury lamps a are used in conjunction with infrared heating lamps at a distance of 150 cm from the animals. The distance is critical since UVB burns can occur.

Institutions that breed giant tortoises do not keep juvenile animals in the same enclosure with adults. At Zurich Zoo young Galapagos tortoises are kept for several years together with adults, when they reach a carapax length of 35 cm, which is with approximately 4 years. It is felt that this increases activity which is considered beneficial for the skeletal development. No accidents have occurred.
Diagnosis of developmental diseases should be made as early as possible. Whereas pyramiding is readily visible, other forms of developmental diseases may not be recognized until the disease has reached an advanced stage. Annual radiographic examinations with a dorso-ventral beam to document skeletal development are part of the routine health examinations in juvenile Galapagos tortoises at Zurich Zoo (Figure 5).

If developmental disorders are diagnosed therapy is challenging. A review of the feeding regime and management is certainly warranted and corrections should be made where needed. Furthermore endoparasitic diseases should be ruled out. Enteral and parenteral doses of calcium and vitamin D₃ are warranted. Antibiotherapy is indicated because secondary bacterial infections take advantage of the reduced immune status of the patient.

If anorexia occurs application of a permanent gastric tube as described in other chelonians may also prove beneficial in giant tortoises. Assisted feeding with a grass meal based formula such as Critical Care (Oxbow Company, Mudock, USA) can be recommended. The total amount of 50 ml/kg is divided into 4 – 6 feedings.

**Biting**

When food amounts were reduced at Zurich Zoo with the aim to reduce growth rates in Galapagos tortoises, increased occurrence of biting between animals was observed. This has not been reported from other institutions that breed giant tortoises. Biting was usually directed against the head or the limbs. Stress, resulting from boredom, hunger or overcrowding, may predispose to biting. This type of aggression should not be confused with cannibalism, that has been observed in fast growing lizards that appear to
have a high caloric demand for development (Donoghue 2006). The wounds are superficial, but if repeated lead to scar formation. At Zurich Zoo the problem could successfully be controlled by introducing fences in the cage, which allow the animals to hide themselves (Figure 6). In addition large pieces of carrots (6 x 0.5 x 0.5 cm) were offered, which occupy the animals for a longer time.

Infectious diseases in juvenile giant tortoises

Respiratory tract disease

The first two Galapagos tortoises that hatched at Zurich Zoo died at the age of 14 and 15 months. The cause of death was a severe interstitial pneumonia. Stress due to increased growth rate may have been an important contributing factor by suppressing immunity in juvenile giant tortoises. Pneumonia is a well recognized problem in tortoise management in general. Several factors contribute to respiratory tract disease. An important predisposing factor is the anatomy of the tortoise’s lower respiratory tract. The trachea has only a primitive mucociliary apparatus, which acts poorly to clear inflammatory exudates from the lungs (O'Malley 2005). Humid cold weather was recognized as a causative agent for respiratory disease in giant tortoises at Phoenix zoo. Other etiopathologies that may lead to pneumonia are endo- or ectoparasites, deficiencies in husbandry, sanitation and nutrition. A new form of stress may become important in the future due to growing transportation activities with juvenile giant tortoises. The increasing success in captive breeding results in larger numbers of juvenile tortoises
being sent to other institutions. During quarantine it is critical to keep animals in an optimal climatic and nutritional environment, to minimize stress.

Although viral, fungal, and parasitic agents have been involved in respiratory tract disease, the majority of pneumonia in chelonians are caused by bacteria. Bacterial pneumonia may occur as primary entity, as an extension of another disease process such as infectious stomatitis, or as the establishment of a normal commensal organism (e.g. *Escherichia coli*) in an abnormal location such as the lung (Murray 1996).

Clinical signs of pneumonia in chelonians usually appear late in the disease process. Inspiratory and expiratory dyspnea (extended neck), anorexia and lethargy may be found. For diagnosis and follow-up of therapy radiographic examination are valuable. Latero-lateral and cranio-caudal views will give the most information. In addition transtracheal or percutaneous lung washes are recommended for culture and sensitivity testing.

Antibiotic therapy follows the guidelines for other tortoises and the choice should be made on the basis of culture and sensitivity testing. Since pneumonia are usually at an advance degree until clinical signs are obvious, it is generally recommended to initiate aggressive antibiotic treatment. Antibiotics me be given paranteral and by nebulization. Nebulization not only allows application at the site of infection. Increased humidity also proves beneficial by promoting proper hydration of the respiratory epithelium and breakup of necrotic and inflammatory debris. Bactericidal drugs are usually the drug of choice. Enrofloxacin should be used cautiously. Casares and Enders (1996) reported one case of an adult 200 kg Galapagos tortoise that showed twice severe side effects after subcutaneous injection of 1000 mg and 500 mg of enrofloxacin (Baytril® 5% and 10%).
Symptoms started one hour after the injection and included hyperexcitation, uncoordinated movements, hypersalivation and profuse diarrhoea. At Zurich Zoo oxytetracycline 10 mg/kg intramuscular every 48 h is usually the initial antibiotic drug of choice. The possible significantly increased bodyweight of giant tortoises compared to the tortoises commonly kept as pets necessitates allometric scaling of dosages to avoid overdoses. Supportive therapy should include daily soaking in lukewarm 0.9 % saline solution, subcutaneous fluids and force feeding. Assisted feeding as described for MBD may be necessary.

**Endoparasites**

Several institutions have reported endoparasitsm in young giant tortoises. In the wild tortoises have a normal parasite burden. Under captive conditions however an imbalance is more likely to occur due to stress factors such as inadequate diet, low temperature or overcrowding. An imbalance of endoparasite may represent a serious threat to giant tortoises and may predispose them to other diseases. *Entamoeba invadens* has repeatedly been diagnosed in juvenile Galapagos tortoises at Zurich Zoo without clinical symptoms. Bloody diarrhea and subsequent dehydration are well-known symptoms. Intra vitam diagnosis is made in fecal samples. Sample should be fixed and shipped using sodium acetate – acetic acid – formalin (SAF) fixative. If *Cryptosporidia* spp. are to be found a fresh fecal sample has to be submitted. Treatment of *Entamoeba* was successful with metronidazole 50 mg/kg orally for 10 days.

Coccidia are other protozoans that have been diagnosed in giant tortoises. Infestation without apparent diseases is termed coccidiasis, in contrast to coccidiosis,
which is used for clinical disease. In the absence of clinical symptoms, such as diarrhea or unthriftyness, treatment is not warranted.

Some parasites are important parts of the intestinal microflora, especially ciliates e.g. *Balantidium* and *Nyctotherus*. Treatment should not be attempted.

Nematodes of the order oxyurids and strongylids have also been diagnosed in juvenile giant tortoises. The clinical significance is unknown. Fenbendazole 50 mg/kg orally for 5 days and pyrantel 5 mg/kg orally with a repeated treatment after two weeks have been used to treat nematodes in juvenile Galapagos tortoises. Häfeli and Zwart (2000) described in different *Testudo* spp. cryptoporidiosis and balantidiosis which they considered etiological agents besides nephropathies and typhlocolitis, for pyramidal shell development.

It is safe to recommended fecal examinations and treatment of endoparasites if they are found. At Zurich Zoo fecal examinations are performed twice a year.

**Conclusions**

Captive breeding and rearing giant tortoises still represents a challenge and little scientific evidence is available on the requirements of juvenile and adult giant tortoises. Zoo veterinarians must know that developmental diseases are the main risk in the raising process. Respiratory tract disease, endoparasites and biting are other pathologic conditions that have been observed in juvenile giant tortoises. The fast growth observed in giant tortoises must controlled by limiting the amount of food and reducing digestibility. Giant tortoises are well adapted to a high fiber, herbivore diet. Special attention must be given to the mineral supplementation and photoenvironment.
Acknowledgement

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References


Table 1 Taxonomy of giant tortoises

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<th>Seychelles Tortoises</th>
<th>Galapagos Tortoises</th>
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<td>Order</td>
<td>Testudines</td>
<td>(Pritchard 1996)</td>
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<td></td>
<td><em>Geochelone gigantea</em> (3 subspecies)</td>
<td><em>Geochelone nigra</em></td>
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Table 2 Anatomical differences between Galapagos (*Geochelone nigra*) and Seychelles tortoises (*Geochelone gigantea*) modified from (Ebersbach 2001)

<table>
<thead>
<tr>
<th></th>
<th><em>Geochelone gigantea</em></th>
<th><em>Geochelone nigra</em></th>
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<tr>
<td>Head</td>
<td>Head similar diameter as neck, rounded ridge of the nose, pointed nose</td>
<td>Head wider than neck, short nose</td>
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<tr>
<td>Prefrontal scales</td>
<td>Large</td>
<td>Small</td>
</tr>
<tr>
<td>Nose</td>
<td>Opening vertical, slit like. Soft tissue flap on the septum nasi allows to close off the cavum nasi proprium → drinking through nose possible</td>
<td>Opening round. No drinking through nose possible</td>
</tr>
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<td>Nuchal scute</td>
<td>Present in 98%</td>
<td>Absent</td>
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<tr>
<td>Caudal scute</td>
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</table>
Legends

Figure 1 Coelioscopy in a 6-year old Galapagos tortoise (*Geochelone nigra*). 1 = juvenile testicle, 2 = intestine.

Figure 2 Coelioscopy in a 4-year old Galapagos tortoise (*Geochelone nigra*). 1 = juvenile ovary with primary follicles, 2 = oviduct, 3 = intestine.

Figure 3 Measurement of the straight carapax length in a 1-year old Galapagos tortoise (*Geochelone nigra*).

Figure 4 Mechanical immobilization of an adult Galapagos tortoise (*Geochelone nigra*).

Figure 5 Dorso-ventral radiography of a clinically healthy 2-year old Galapagos tortoise (*Geochelone nigra*). Note the large amounts of sand that are present in the large intestine. A microchip has been implanted in the left prefemoral area.

Figure 6 Fences in this enclosure of juvenile Galapagos tortoises (*Geochelone nigra*) help reducing biting incidence.